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METHOD AND SYSTEM FOR DETERMINING THE POINT OF ENGAGEMENT OF A CLUTCH OPERABLE VIA AN ACTUATING DEVICE

~~Background Information~~FIELD OF THE INVENTION

The present invention relates to a method and a system for determining the point of engagement of a clutch operable via an actuating device~~, having the features of the preamble of independent Claim 1.~~.

BACKGROUND INFORMATION

Efficient vehicle dynamics are achievable in vehicles having all-wheel drive via a controlled distribution of the drive power to the front and rear axles. A transfer case (VG) is used as an actuator for power distribution. The main part of this transfer case is a multidisk clutch (MSK) which transfers the torque to the power take-off side of the vehicle as a function of the pressing force exerted on its lamellas. The mechanical construction of the transfer case allows the precision distribution required within the specification, exclusively by exerting a force on the actuating mechanism. This actuating force is generated, for example, using an eccentric disk and a pantograph mechanism, in general by a geared or positioning motor (GM), in particular by a DC motor having a worm gear. Figure 1 shows the actuating chain of the transfer case and its components: DC motor (101), worm gear (102), eccentric disk (103), pantograph (104), and multidisk clutch (105).

For cost reasons, force or torque sensors are frequently omitted in the design of the geared motor's control. Instead, the actuating characteristic of the transfer case is saved in the control unit (SG) in the form of a torque-actuator travel characteristic curve (201) (Figure 2), whereby the actuating intervention is attributed to a positioning of the eccentric disk, i.e., to a position regulation of the geared motor. The central point of the characteristic curve is the engagement point (202) also known as

the kiss point. This is the point at which the multidisk clutch begins to transfer torque. The multidisk clutch setting as a function of the length of operation causes an angular shift in the characteristic curve stored in the control unit.

A calibration procedure may be used to detect the shift in the point of engagement. The speed-regulated geared motor is used here as a sensor to reconstruct the point of engagement. The eccentric disk is rotated by the positioning motor at a constant speed against the actuator load torque generated by the clutch. If the motor current is then recorded using measuring technology (Figure 3), it may be averaged at three characteristic angular positions of the eccentric disk. Two straight lines (301, 302) may then be constructed using the three current/angle points, the point of intersection of which would represent the point of engagement. Straight line (301) is assumed here to be a horizontal line.

However, the motor current represents the actuating torque only for a constant and precisely known transmission efficiency. For the positioning motors and actuating mechanisms normally used, the efficiency varies not only as a function of the individual component and the service life, but also, for example, as a function of the worm wheel angle (which tooth of the worm wheel is engaged). In the case of speed-regulated operation, an efficiency which varies over the worm wheel position results in a current excitation, i.e., in a local distortion of the current characteristic curve, Figure 3. Such a distortion, if located in the range of the averaging points, results in erroneous determination of the point of engagement.

SUMMARY OF THE INVENTION

Therefore, a special triggering of the positioning motor and evaluation of the system quantities motor current and worm wheel

speed are used. The positioning motor is triggered during calibration via a cascaded current/speed regulator, and the system quantities motor current, motor speed (worm wheel speed) and rotational angle position (worm wheel angle) are recorded. Active speed regulation causes the positioning motor to rotate the eccentric disk at a constant speed to a worm wheel angle s1, which is located in the free travel path of the clutch mechanism. Starting at s1, the regulator states are frozen, whereby the positioning motor rotates the eccentric disk in a voltage-controlled manner to a standstill against the increasing load torque of the clutch actuator. The obtained signal curves of motor current and worm wheel speed = eccentric disk speed, Figure 4, are thus freed from the influence of the regulator and thus from an excitation which acts thereby as interference. Two signal curves are obtained, which may be used for determining the point of engagement. The application of the linear regression method, applied to the current and speed curves regarding intervals (401) and (402), is characterized by higher robustness against local transmission efficiency fluctuations than is the case when only the current curve is evaluated point-by-point.

~~Construction~~

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the actuating chain of the transfer case and its components, a DC motor (101), a worm gear (102), an eccentric disk (103), a pantograph (104), and a multidisk clutch (105).

Figure 2 shows a torque-actuator travel characteristic curve.

Figure 3 shows a local distortion of the current characteristic curve.

Figure 4 shows the obtained signal curves of motor current and worm wheel speed = eccentric disk speed.

Figure 5 shows the current regulator, the speed regulator, the controller and the analyzer arrangement.

Figure 6 shows the signal-time curves.

Figure 7 shows a signal flow diagram of the control.

Figure 8 shows a typical motor current signal curve specified by the controller.

Figure 9 shows the signal flow diagram of the analysis.

DETAILED DESCRIPTION

DC transmission motor (101)~~,~~ of Figure 1, i.e., the positioning motor, is triggered via an H bridge (502)~~. Two~~ of Figure 5. In Figure 5, two sensors (503, 504) for detecting the motor speed and the worm wheel position, respectively, are mounted on the positioning motor. A further sensor (505) is used for measuring the current. Current regulator (506) generates a control voltage from the current measured by current sensor (505) and the setpoint current specification, i.e., the output quantity of speed regulator (507); this control voltage is used as an input quantity of H bridge (502). Current regulator (506) ~~is preferably designed as~~may be a PI regulator having an anti-reset-windup function and the option to freeze the regulator output quantity and the internal regulating states as a function of a control quantity.

Speed regulator (507) receives its input quantity, the measured motor speed, from speed sensor (503) and the motor speed setpoint value from controller (508). Speed regulator (507) ~~is preferably designed as~~may be a PI regulator having an extended anti-reset-windup function which takes into account the state of the current regulator, and the option to freeze the regulator output quantity and the internal regulating states as a function of a control quantity. Controller (508) controls the entire calibration process. The required signal quantities worm wheel angle (504), worm wheel speed (509), and motor current (505) are made available by the corresponding sensor units or converting

units (509); the worm wheel speed or eccentric disk speed may be computed from the motor speed of the positioning motor as a derived quantity using the known transmission ratio of the worm gear. The regression analysis of the motor current and worm wheel speed signal curves plotted against the worm wheel angle is performed in analyzer unit (510), configured and activated by the control unit.

The overall function is divided into function units control and evaluation or analysis. The controller outputs the motor setpoint speed to the speed regulator and, at the same time, activates the function of the speed regulator and the current regulator. The signal-time curves illustrated in Figure 6 are obtained. The speed-regulated state remains activated until the worm wheel reaches position sFix. Thereafter the controller causes the regulator to freeze its manipulated variables as a function of the analysis mode. There are two modes here.

In mode 1 the manipulated variable of the current regulator is frozen (switched to constant) and all integral components of the regulator are reset. The analysis is performed at a constant voltage. In mode 2, the current regulator remains active; the controller causes only the speed regulator to freeze its manipulated variables. The analysis is performed at a constant current. After running through all regression intervals, the current regulator is reactivated (mode 1) and the controller outputs a current setpoint value which causes the positioning motor to move back to its initial position. This terminates the calibration process. Only one mode is allowed to be active at each calibration; this makes it possible to perform two calibration operations (mode 1, mode 2) sequentially. The calibration operations are best performed when the internal combustion engine of the motor vehicle is started or when the vehicle is at a standstill with the clutch disengaged. Figure 7 shows a signal flow diagram of the control.

Analysis

Two regression analyses for each signal curve are performed in the analysis as a function of the mode selected by the controller. In mode 1, it is applied to the worm wheel speed signal curves plotted against the worm wheel position and, optionally, also to the motor current signal curves plotted against the worm wheel position. In mode 2, this application only makes sense for the worm wheel speed curve plotted against the worm wheel position due to the constant current regulation. Since the method is identical in principle for both curves, it is explained here only for the motor current as an example.

The typical motor current signal curve specified by the controller is shown in Figure 8. In first regression range (801), a linear regression is performed recursively using sampled pairs of values (s.I). The resulting straight regression line is stored using two parameters: straight line slope and ordinate segment. Subsequently, regression range (802) is run through within the controlled calibration process. A linear regression is performed again in this range, and the obtained straight regression line is stored again as the pair of parameters: straight line slope and ordinate segment. After all regression ranges have been run through, the point of intersection of the two straight regression lines is computed, and thus the kiss point is determined.

In general, the slope of the straight line in regression range (802) is approximately known, because the clutch characteristic barely changes in this direction and is therefore also known from previous analyses. A filter function may therefore be implemented which evaluates the range of confidence of the sampled signal values. Local regression ranges which are subsets of the original ranges and whose upper limits form the newly sampled pairs of values are formed within regression ranges (801), (802). Local straight regression lines are formed in a similar manner. If their slope differs from the expected slope, the latest sampled pair of values is weighted using a lower weight in the regression analysis or ignored altogether. The signal flow diagram of the analysis is shown in Figure 9.

In summary, it is possible to state that a calibration process is performed to determine the point of engagement. A cascaded speed-current regulator is used. Positioning motor GM runs through the entire actuating range in part in the speed-regulated mode, in part in the voltage-regulated mode. The run is started using speed regulation. Starting from a predefined worm wheel position, the manipulated variables of the regulator are frozen (mode 1: current regulator deactivated; mode 2: current regulator active, speed regulator deactivated). The signal curves, mode 1: current as a function of the worm wheel position and worm wheel speed as a function of the worm wheel position, and mode 2: only worm wheel speed as a function of the worm wheel position, are recorded.

There is a fixedly defined regression range within the free travel path of the actuator. The signal curves are subjected to a linear regression here. The straight regression lines for speed and current are determined recursively. There is a second regression range as a function of the worm wheel speed or motor current. Here again the signal curves are subjected to a linear regression.

The local slopes are determined using linear regression within smaller subintervals whose upper limit is the currently sampled data pair. The comparison of the local slope with the expected slope, e.g., from previous calibrations, determines the weighting factor used for forming the new pairs of values in the main regression. The straight regression line is determined for this purpose after running through the second regression range. The point of intersection of the two straight regression lines is computed for each signal curve (as a function of the mode). The point of engagement (kiss point) is the point of intersection of the two straight regression lines.

~~Abstract~~ABSTRACT OF THE DISCLOSURE

A method and a system for determining the point of engagement of a clutch ~~(MSK)~~ of a motor vehicle operable via an actuating device, in particular of a clutch situated in a transfer case of a motor vehicle having all-wheel drive, the actuating device having a positioning motor ~~(GM)~~ which is electrically drivable, the output of the positioning motor providing a motor torque and a motor speed, and the motor being operationally linked to an actuating mechanism ~~(102, 103, 104)~~ which actuates the clutch ~~(MSK)~~ and being operable via a control unit ~~(508)~~. It is provided that, to determine the point of engagement, a constant voltage is applied to the positioning motor ~~(GM)~~ in a first operating mode and, at the same time, the motor speed is detected as a function of the rotational angle position and in particular additionally the motor current is detected as a function of the rotational angle position, and/or a constant current is applied to the positioning motor ~~(GM)~~ in a second operating mode and the motor speed is detected as a function of the rotational angle position; and the point of engagement is determined from the detected values of the motor speed, that are a function of the rotational angle position, and, in particular, in addition, from the values of the motor current.

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